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MICROWAVE TUBE WITH RESONANT DISCHARGE GAP

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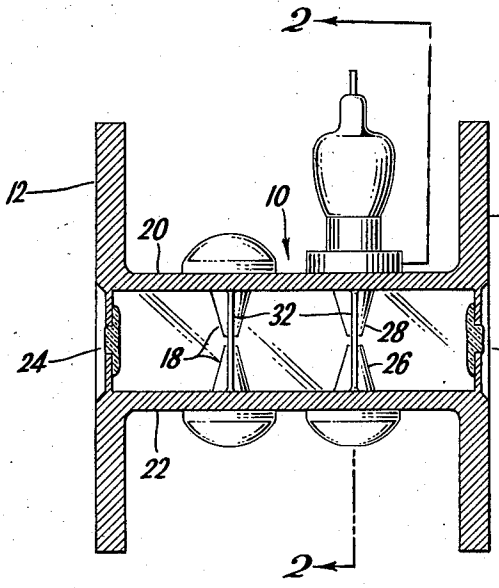


Fig. 1

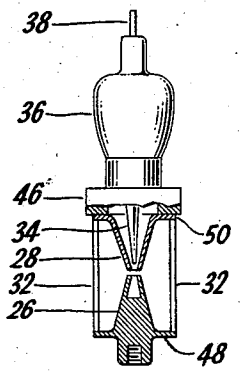


Fig. 3

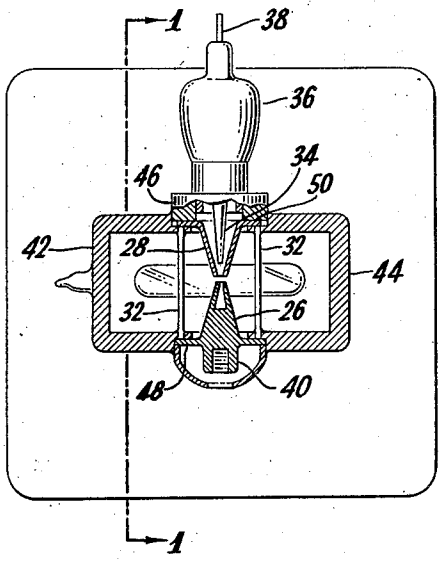


Fig. 2

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MICROWAVE TUBE WITH RESONANT DISCHARGE GAP

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6 Claims. (Cl. 315—41)

The present invention relates to waveguide structures and in particular to transmit-receive tubes and the like having discharge gap electrodes.

For some years, transmit-receive switch tubes or duplexers have been used in radars where a common antenna system is utilized both by a pulse transmitter and by a sensitive receiver, the transmit-receive switch operating to short-circuit the wave guide communicating to the receiver from the antenna during the high-level pulses emitted by the transmitter. These tubes include a pair of discharge gap electrodes, in the customary design, and have been variously assembled in cavity resonators, and in various waveguide configurations. At the time of the high-level micro-wave pulse, a discharge develops across the gap electrodes, resulting in an ionized discharge in the tube, which is gas-filled, and the high level energy then is reflected from the delicate receiver. Weak signals received at the antenna are transmitted through the transmit-receive tube which is not ionized by such signals. Similar tubes having discharge gap structures include the attenuator tube that is effective to limit the sensitivity of a receiver during a predetermined time after each transmitter pulse, and combined attenuator and transmit-receive tubes. The present invention will be recognized as having application to a variety of tubes as indicated, but is herein explained in connection with a broad-band transmit receive tube to which the invention is particularly applicable.

The broad-band type of transmit-receive tube usually includes a length of wave guide with multiple discharge gaps disposed across the waveguide. The gap electrodes, by virtue of their proximity to each other, introduce a capacitance which would raise complex external impedance matching problems if the capacitance of each gap were not taken into account within the transmit-receive tube structure. In rectangular waveguide transmit-receive tubes with the discharge gap electrodes extending toward each other from the broad top and bottom walls of the wave guide, it has been customary practice to provide baffles on both sides of the gap electrodes, formed as blades extending inward through slots in the narrow side walls and from top to bottom of the wave guide. Slots have been cut in the waveguide, and then the blades have been inserted and brazed in place. This construction is shown, for example, in Patent No. 2,611,109 issued September 16, 1952, to E. T. Casellini.

Broad-band transmit-receive tubes customarily include two or more discharge gaps, and for each such gap, a pair of baffles has been required. This procedure is quite costly and uncertain because of the extensive brazing operations involved. A number of tubes may leak out of a large production run of tubes, so that partly completed but leaky tubes would be rejected and a corresponding burden of inspection is created. Transmit-receive tubes, it should be understood, are hermetically sealed and contain a particular mixture of ionizing and quenching gases, generally at a small fraction of atmospheric pressure. Any leakage that would change the composition of the gas or its pressure should therefore be avoided.

In applying the present invention, a pair of discharge gap electrodes is associated with a pair of posts. The discharge gaps which terminate a short distance from each other represent capacitance and the posts represent inductance, the gap electrodes and the posts together constituting a resonant circuit. Accordingly any tendency of the gap electrodes to introduce reflections as a localized capacitive reactance is neutralized by the posts as inductive reactances at that location in the wave guide. The positions, shapes and the cross-section of the posts influence their inductive effect. In transmit-receive tubes where a number of discharge gaps are distributed one-quarter-wave length away from each other at the mean frequency of the band for which the device is intended, each pair of discharge electrodes is associated with a pair of posts.

The posts or wires advantageously are disposed relatively close to the discharge gap electrodes. In this position they extend across the waveguide in the same region where the discharge gap electrodes themselves are mounted, and are accordingly susceptible to a minimum of brazing difficulties, in respect to any tendency to develop leaks due to imperfect brazing, and are most readily assembled in place.

This invention provides a new resonant structure, involving a pair of discharge gap electrodes resonated by a pair of posts. This structure when incorporated in a rectangular waveguide extending from the opposed broad walls of the guide vastly simplifies fabrication of transmit-receive tubes and the like, and attains further advantages as will appear.

The nature of the invention and its various features of novelty and objects will be better appreciated from the following detailed disclosure of an illustrative embodiment shown in the accompanying drawings. In the drawings:

Fig. 1 is a longitudinal cross-sectional view of an illustrative transmit-receive tube along the line **1—1** of Fig. 2;

Fig. 2 is a cross-sectional view of the transmit-receive device of Fig. 1 along the line **2—2** in Fig. 1; and

Fig. 3 is a lateral view of a discharge gap and post assembly as a unit in readiness for mounting as in a waveguide to constitute a transmit receive switch tube like that in Figs. 1 and 2.

Referring now to Figs. 1 and 2 showing an illustrative embodiment of the invention, a length of rectangular metal waveguide **10** is shown having a pair of end flanges **12, 14** provided for joining the tube to other structures in the waveguide system in which the tube is to be used. One pair of discharge gap electrodes **18** is disposed between the broad top wall **20** and the broad bottom wall **22** of the waveguide, approximately one-quarter wavelength away from window **24** formed as the closure at one end of the waveguide. That window has a small opening covered by glass and is designed as a component resonant at the center frequency of the band for which the tube is to be used.

A second pair of discharge gap electrodes **26, 28** is separated from the first pair **18** by a quarter-wave length, and a second window **30**, closing the opposite end of guide **10**, is separated from electrodes **26, 28** similarly by a quarter-wave length. Electrodes **18** are like electrode **26** in construction.

Associated with each pair of gap electrodes **18** and **26, 28** there is a pair of metal posts or wires **32** which, extending from the broad walls **20, 22** of the rectangular waveguide, introduce inductance which resonates with the capacitive effect of the discharge gap electrodes, when

operated in the usual mode. In this mode, a signal potential is developed between the broad walls of the waveguide and hence between the gap electrodes.

Discharge gap electrode **28** is hollowed and contains a keep-alive electrode **34** that is supported by a glass insulator **36** and has an external terminal **38** to which a voltage may be applied relative to electrode **28**. Features of this construction are more fully disclosed and claimed in copending application Serial No. 237,258, filed July 17, 1951, by Paul E. Gates, now Patent No. 2,740,186. The limited glow discharge produced at the tip of the keep-alive electrode by the applied potential makes available a small volume of ionized gas for facilitating prompt response of the transmit-receive tube to the high level micro-wave bursts of transmitter energy which are periodically impressed on the tube, and which are reflected when the ionized breakdown occurs and thus are not transmitted through the transmit-receive tube to the receiver. Between these bursts, the tube is supposed to transmit low-level signals and in this function is to act as nearly like an inert length of waveguide as possible, and therefore should contain a bare minimum of localized impedances. This is realized for a limited band of frequencies, by the multiple quarter-wave spaced resonators.

Electrode **26** and one of the electrodes **18** is formed with a female-threaded bore **40** which is externally accessible for tuning adjustment. By inserting a threaded tool and deforming the base flange of the electrode, it is possible to shift its position laterally and endwise toward and away from the opposed discharge gap electrodes **28**, to that limited extent which may be necessary to perfect the tuning. When properly tuned, discharge electrodes **26** and **28** coact with posts **32** to resonate at the center frequency of the band for which the device is designed.

Posts **32** as resonating elements contrast in many ways with the baffles or blades previously used in this type of tube. Such blades could not be readily adjusted. Once they were inserted and brazed in place all practical tuning adjustments had to be made by deforming the support of a gap electrode and if this was insufficient the device would be rejected. Those blades, brazed in slots in the waveguide, involve serious possibility of leakage developing, particularly where a large number of blades are required in a number of gaps.

As seen in Fig. 2, the posts **32** terminate in the same region as that used for sealing the gap electrodes themselves and accordingly minimize the extent of the brazing to be done, and this correspondingly minimizes the occurrence of leaky tubes. Additionally, the posts can be deformed as by lateral deflection before the windows are sealed in place should it become necessary to adjust their inductive effects. This may be occasioned either because the tuning range of the gap electrode may be inadequate or where it is desired to maintain a predetermined spacing between the gap electrodes.

The tub of Fig. 2 may be assembled variously. For example, after the top and bottom walls **20** and **22** have been formed with recessed seats for the gap electrodes, they may be drilled with aligned holes to receive posts **32**. The electrodes may then be assembled as illustrated, with seated flanges or bases **48**, **50** of the conical electrodes **26**, **28**, and while held with brazing preforms in a suitable brazing jig in a hydrogen furnace or the like the parts are finally united. After the windows **24** and **30** are similarly brazed in place, the device is a hermetically sealed unit. It is exhausted and then filled at a low pressure with a suitable gas, as for example, argon and water vapor at equal partial pressures for a total pressure of 10 mm. of mercury.

The tuning adjustment may be effected by deforming the posts **32** or if they should be unintentionally deformed, their configuration may be corrected before assembly of the windows; and the final tuning adjustment can be effected as heretofore by adjusting electrode **26**. As seen in Fig. 2, the flanges of electrodes **26** and **28** cross the ends of posts **32**; and when the flanges are brazed in place, there need be no special concern for hermetic sealing of the post ends.

The structure of Figs. 1 and 2 may be modified somewhat to take further advantage of the resonant gap-and-post structure. As shown in Fig. 3, where corresponding numbers are used to denote corresponding parts, this may be formed as an entity, whose geometry can be accurately established without any obstruction from the waveguide, the posts in this assembly serving to fix the relative orientation of the gap electrodes even before the assembly is inserted and united to the waveguide using flange **46** as a guide that seats in a recess in the waveguide provided for it. This control over the geometry of the resonant gap and iris structure, made possible by utilizing inductive posts in place of baffles, is a further advantage attained by the invention.

Additional changes in matters of detail and varied application of the various aspects of the invention will readily occur to those skilled in the art in the light of this disclosure; and accordingly the appended claims should be accorded that broad latitude of interpretation as is consistent with the spirit and scope of the invention.

What is claimed is:

1. A broad-band transmit-receive tube, including a length of rectangular waveguide having signal-transmitting resonant windows at the ends thereof, said waveguide being hermetically sealed and containing a mixture of ionizing and quenching gases at low pressure, multiple pairs of discharge gap electrodes, the electrodes of each pair extending toward each other from the opposed broad walls of the rectangular waveguide and having flanges sealed to the waveguide, said pairs of discharge gap electrodes being spaced from each other and from the windows by quarter-wave intervals, and a post at each side of each pair of discharge gap electrodes extending from one of the opposed broad walls of the rectangular waveguide to the other at the flanges of the discharge gap electrodes and resonant with the adjacent discharge gap electrodes at a frequency within the operating band of the tube.

2. A gaseous discharge tube, including a length of waveguide providing a micro-wave transmission path, and multiple resonant discharge gap assemblies distributed along the waveguide at quarter-wave separation, said assemblies each including a pair of discharge gap electrodes and a pair of posts contacting the waveguide only at the base of each discharge gap electrode, said posts being readily deformable for adjustment of their inductive effect.

3. A micro-wave device including a length of waveguide providing a waveguide path, a pair of electrodes therein extending toward but spaced from each other, and wires deformable for adjustment of their inductive effect disposed at opposite sides of said electrodes and extending from the base of each of said electrodes to the base of the other, the electrodes and wires constituting a resonant system.

4. A micro-wave device, including a gas-filled envelope, a pair of discharge gap electrodes disposed therein and extending toward each other, and a pair of wires deformable for adjustment of their inductive effect and joined to both said electrodes at the opposite extremities thereof.

5. A micro-wave device including an assembled pair of discharge gap electrodes having gap portions close to each other and base portions remote from each other, and a pair of wires laterally separated from each other and from the gap portions, said wires being deformable for adjustment of their inductive effect and extending from the base portion of each electrode to the base portion of the other.

6. A gaseous discharge tube, including a length of waveguide providing a micro-wave transmission path,

and multiple resonant discharge gap assemblies distributed along the waveguide at quarter-wave separation, said assemblies each including a pair of discharge gap electrodes mounted at opposite sides of the waveguide and a pair of posts deformable for adjustment of their inductive effect extending from one of said sides of the waveguide to the other of said sides of the waveguide and contacting said sides only at the base of each discharge gap electrode, said posts being resonant with said gap electrodes at an operating frequency of the tube.

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